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AD NUMBER
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FROM: **Controlling DoD Organization: Army Feltman Ammunition Laboratory, Picatinny Arsenal, NJ. Oct 1956.**
AUTHORITY
5 jun 1981 per document marking; arradcom ltr, 13 feb 1980

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AL REPORT 2372

USE OF INERT NOSE PADS AND CONTROLLED FUZING TO IMPROVE HEP SHELL PERFORMANCE (~~C~~)

BERNARD A. RAUSCH

EXCLUDED FROM GENERAL
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OCTOBER 1956

Regraded Unclassified
By authority of DTIC (AD 111 465)
Date 5 June 81

SAMUEL FELTMAN AMMUNITION LABORATORIES
PICATINNY ARSENAL
DOVER, N. J.

ORDNANCE PROJECT TA1-5002H
DEPT. OF THE ARMY PROJECT 5A04-01-001

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SECURITY REMARKING REQUIREMENTS

DOD 5200.1-R, DEC 78

REVIEW ON 28 OCT 76

EXCLUDED

FROM GENERAL CLASSIFICATION SCHEDULE
IN ACCORDANCE WITH
INFORMATION SECURITY PROGRAM REGULATION

DATED - JULY 1972

DOD 5000.1R & EXECUTIVE ORDER 11652
(EXECUTIVE ORDER 10501 AMENDED)

BY

Defense Documentation Center
Defense Supply Agency
Cameron Station
Alexandria, Virginia 22314

DEC 1972

AD 111465

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CORRECTION SHEET

Samuel Feltman Ammunition Laboratories
Picatinny Arsenal
Dover, N. J.

DEC - 6 56 - 1 PM

REPORT NUMBER	TR 2372
REPORT DATE	October 1956
AUTHOR	Bernard Rausch
TITLE	Use of Inert Nose Pads and Controlled Fuzing to Improve HEP Shell Performance (C)

Please correct the Picatinny Arsenal report identified above as shown below:

Page	Par.	Correction	
Table of Contents	Fig 3	Change	
		From:	Modified M91A1 Base-Detonating Fuze
		To:	M91A1 Base-Detonating Fuze
1	Summary	Change	
		From:	1500
		To:	2000
2	1	Change	
		From:	1500
		To:	2000
4	Table 1	Change	Lot PA-E-18581, Filler and Fuze Column
		From:	Inert Nose pad, Comp A-3 and Mod M91A1
		To:	Inert nose pad, Comp A-3 and M91A1
7	Table 4	Change	Lot PA-E-18580 Filler and Fuze Column
		From:	Comp A-3 and M91A1
		To:	Comp A-3 and Mod M91A1
12	18	Change 1st sentence	
		From:	The fuzes used in Lots PA-E-18581 and -18582 were modified, in accordance with Figure 3, to have an average percussion plunger travel of .030 inch ("A" dimension .480 inch).
		To:	The fuzes used (Lots PA-E-18581 and 18582) were M91A1 Base Detonating Fuzes (Fig 3), modified to have an average percussion plunger travel of .030 inch.
22	Fig 3	Substitute enclosed Dwg 73-2-239 for Dwg P-87758	

DEC 1

Correction Date 19 November 1956

56AA 61385

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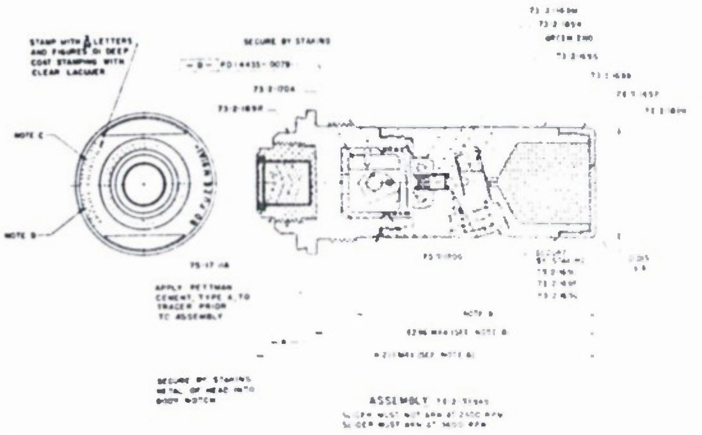

ASSEMBLY 73-2-239A

SLIDER MUST NOT ARM AT 2400 RPM
SLIDER MUST ARM AT 3400 RPM

NOTES

A. [illegible]
C. LOT NUMBER
D. MONTH AND YEAR LOADED

LIST OF SPECIFICATIONS AND STANDARDS

LINE NO.	LIST OF SPECIFICATIONS AND STANDARDS	SPEC OR STD NO.	REQUIRED BY
1	AMMUNITION (EXCEPT SMALL ARMS AMMUNITION) GENERAL SPEC FOR	MIL-A-2550	[illegible]
2	ALUMINUM ALLOY, DIE CASTING	[illegible]	[illegible]
3			
4	[illegible] STEARATE	[illegible]	[illegible]
5	BRASS, COMMERCIAL, BARS, PLATES, RODS, SHAPES, ETC	[illegible]	[illegible]
6			
7	CALCIUM STEARATE	[illegible]	[illegible]
8	CEMENT, PETTMAN	[illegible]	[illegible]
9	CORK COMPOSITION, GASKET AND SHEET	[illegible]	[illegible]
10			
11	DETONATORS, LOADING, ASSEMBLING AND PACKING	[illegible]	[illegible]
12			
13	FINISHES, PROTECTIVE FOR IRON AND STEEL PARTS	[illegible]	[illegible]
14	FUZE, BASE DETONATING, [illegible] LOADING, ASSEMBLING AND PACKING	[illegible]	[illegible]
15	FUZE, BASE DETONATING, METAL PARTS FOR	[illegible]	[illegible]
16	GRAPHITE (FOR USE IN AMMUNITION)	[illegible]	[illegible]
17			
18	LACQUER, CELLULOSE NITRATE AND THINNER	[illegible]	[illegible]
19	LACQUER, RUST INHIBITING, CLEAR	[illegible]	[illegible]
20			
21			
22			
23			
24			
25			
26	STEEL, CARBON, BARS (GENERAL PURPOSE)	[illegible]	[illegible]
27	STEEL, CARBON AND ALLOY, SHEETS AND STRIPS	[illegible]	[illegible]
28			
29	TETRYL	[illegible]	[illegible]
30	VARNISH, PHENOL FORMALDEHYDE RESIN	[illegible]	[illegible]
31			
32	WIRE, BRASS	[illegible]	[illegible]
33	WIRE, PHOSPHOR BRONZE, SPRING	[illegible]	[illegible]
34	WIRE, STEEL (CARBON), SPRING, MUSIC	[illegible]	[illegible]
35			
36	ZINC BASE ALLOY, DIE CASTINGS	[illegible]	[illegible]
37	ORDNANCE [illegible] (SURFACE ROUGHNESS)	[illegible]	[illegible]
38	STANDARD FOR DIMENSIONING AND TOLERANCING	[illegible]	[illegible]
39	SURFACE ROUGHNESS, WAVINESS AND LAY	[illegible]	[illegible]
40			

* THE SPECIFICATION AND STANDARD NUMBERS ARE BASIC NUMBERS ONLY. [illegible] TO ITS BASIC NUMBER

SUPERSEDES 73-2-239 AND 73-2-240 IN PART [illegible]

LIST OF PARTS

LINE NO.	NAME OF PART	NO. REQ	PIECE MARK	SIZE OR FORM	KIND	GRADE	SPEC NUMBER	[illegible]	[illegible]	REMARKS
1	ASSEMBLY		73-2-239A					[illegible]		
2										
3	BODY LOADING ASSEMBLY		[illegible]					[illegible]		
4	DETONATOR ASSEMBLY [illegible]	1	[illegible]					[illegible]		
5	PERCUSSION PLUNGER ASSEMBLY		[illegible]				[illegible]	[illegible]		
6	SLIDER LOADING ASSEMBLY		[illegible]					[illegible]		
7	TRACER [illegible] LOADING ASSEMBLY		[illegible]					[illegible]		
8	BODY	1	[illegible]	BAR	STEEL	[illegible]	[illegible]	[illegible]		[illegible]
9	BODY PLUNGER	1	[illegible]	ROD	BRASS, COMMERCIAL, HALF HARD	COMP B	[illegible]	[illegible]		
10										
11	CHARGE, BOOSTER	1	[illegible]		TETRYL	[illegible]	[illegible]	[illegible]		
12	CHARGE, BOOSTER LEAD	1	[illegible]		TETRYL	[illegible]	[illegible]	[illegible]		
13	CHARGE, SLIDER	1	[illegible]		TETRYL	[illegible]	[illegible]	[illegible]		
14	LOWER PELLET, BOOSTER	1	[illegible]		TETRYL	[illegible]	[illegible]	[illegible]		
15	UPPER PELLET, BOOSTER	1	[illegible]		TETRYL	[illegible]	[illegible]	[illegible]		
16	CUP, BOOSTER	1	[illegible]	STRIP	BRASS, COMMERCIAL, HALF HARD	COMP C	[illegible]	[illegible]		[illegible]
17										
18	CUSHION, DETONATOR	1	[illegible]	SHEET	CORK COMPOSITION	CLASS I	[illegible]	[illegible]		[illegible]
19										
20										
21	[illegible] FIRING PIN	1	[illegible]	BAR	STEEL	[illegible]	[illegible]	[illegible]		[illegible]
22	HEAD	1	[illegible]	BAR	STEEL	[illegible]	[illegible]	[illegible]		[illegible]
23	HOLDER, DETONATOR	1	[illegible]	ROD	BRASS, COMMERCIAL, HALF HARD	COMP [illegible]	[illegible]	[illegible]		[illegible]
24	HOUSING, PLUNGER	1	[illegible]	BAR	STEEL	[illegible]	[illegible]	[illegible]		[illegible]
25										
26	PIN	1	[illegible]	ROD	BRASS, COMMERCIAL, HALF HARD	COMP B	[illegible]	[illegible]		
27	PIN, FIRING	1	[illegible]	[illegible]	BRASS, COMMERCIAL, HALF HARD	COMP [illegible]	[illegible]	[illegible]		
28	PIN, SAFETY	1	[illegible]	ROD	BRASS, COMMERCIAL, HALF HARD	COMP B	[illegible]	[illegible]		[illegible]
29										
30										
31										
32	SLIDER, RETAINER	1	[illegible]	ROD	BRASS, COMMERCIAL, HALF HARD	COMP [illegible]	[illegible]	[illegible]		
33	SLIDER	1	[illegible]	ROD	BRASS, COMMERCIAL, HALF HARD	COMP [illegible]	[illegible]	[illegible]		
34	SPRING, SLIDER	1	[illegible]	WIRE	STEEL, MUSIC SPRING	COMP [illegible]	[illegible]	[illegible]		[illegible]
35	SPRING, RETAINING	1	[illegible]	WIRE	STEEL, MUSIC SPRING	COMP [illegible]	[illegible]	[illegible]		[illegible]
36	SPRING, SAFETY PIN	1	[illegible]	WIRE	BRASS	COMP [illegible]	[illegible]	[illegible]		[illegible]
37										
38										
39					[illegible] STEARATE		[illegible]			
40					GRAPHITE	[illegible]	[illegible]			
41										
42					VARNISH, PHENOL FORMALDEHYDE RESIN		[illegible]			
43					CALCIUM STEARATE		[illegible]			
44					LACQUER, RUST INHIBITING, CLEAR		[illegible]			
45					CEMENT, PETTMAN	TYPE A	[illegible]			
46										
47										
48										

- ALTERNATIVE MATERIAL: ZINC BASE ALLOY DIE CASTINGS, CLASS A, SPEC [illegible]
- ALTERNATIVE MATERIAL: PHOSPHOR BRONZE WIRE, SPRING TEMPER, GRADE A, SPEC [illegible]
- ALTERNATIVE MATERIAL: COMMERCIAL BRASS FORGING COMPOSITION A, SPEC [illegible]
- ALTERNATIVE MATERIAL: COMMERCIAL BRASS ROD OR SHAPE COMPOSITION [illegible] HALF HARD, SPEC [illegible]
- ALTERNATIVE MATERIAL: STEEL [illegible] AS COLD FINISHED SPEC [illegible]
- ALTERNATIVE MATERIAL: STEEL [illegible] AS COLD FINISHED SPEC [illegible]
- ALTERNATIVE MATERIAL: STEEL [illegible] SPEC [illegible]
- ALTERNATIVE MATERIAL: LACQUER, CELLULOSE NITRATE, TINTED GREEN, TYPE I, SPEC [illegible]
- ALTERNATIVE MATERIAL: STEEL [illegible] AS COLD FINISHED SPEC [illegible]
- ALTERNATIVE MATERIAL: ALUMINUM BASE ALLOY DIE CASTINGS, CLASS [illegible], SPEC [illegible]
- [illegible]
- [illegible] TYPE [illegible] CLASS [illegible] SPEC [illegible]
- [illegible] FINISH: TYPE [illegible] CLASS [illegible] SPEC [illegible]
- ALTERNATIVE MATERIAL: STEEL [illegible] AS COLD FINISHED, SPEC [illegible]

LIST OF DRAWINGS

LINE NO.	LIST OF DRAWINGS	DRAWING NUMBER
1	ASSEMBLY	[illegible]
4	[illegible]	[illegible]
5	DETAIL	[illegible]
6	DETAIL	[illegible]
7	DETONATOR [illegible] LOADING ASSEMBLY	[illegible]
9	[illegible] CONTAINER [illegible]	[illegible]
11	[illegible]	[illegible]
12	TRACER [illegible] LOADING ASSEMBLY	[illegible]

FUZE, BASE DETONATING [illegible] ASSEMBLY

73-2-239

7/78

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DDC REPORT BIBLIOGRAPHY   SEARCH CONTROL NO. BF035N

AD- 111 465   19/1   19/4
PICATINNY ARSENAL DOVER N J FELTMAN RESEARCH LABS

USE OF INERT NOSE PADS AND CONTROLLED FUZING TO
IMPROVE HEP SHELL PERFORMANCE   (C)

OCT 56   1V   RAUSCH, BERNARD A.;
REPT. NO. TR2372
PROJ: TA1 5002H

EXCL.   CONFIDENTIAL REPORT

DESCRIPTORS: *ARMOR, *HIGH EXPLOSIVE AMMUNITION,
*VULNERABILITY, EFFECTIVENESS, PROJECTILES, TESTS   (M)

UNCLASSIFIED

DDC REPORT BIBLIOGRAPHY SEARCH CONTROL NO. BFK34D

Apr 81

AD- 111 465 19/1 19/4

PICATINNY ARSENAL DOVER N J FELTMAN RESEARCH LABS

Use of Inert Nose Pads and Controlled
Fuzing to Improve HEP Shell Performance. (U)

OCT 56 24P RAUSCH,BERNARD A.;
REPT. NO. TR2372
PROJ: TA1 5002H

UNCLASSIFIED REPORT

C-4020

DESCRIPTORS: *ARMOR, *HIGH EXPLOSIVE AMMUNITION,
*VULNERABILITY, EFFECTIVENESS, PROJECTILES, TESTS (U)

USE OF INERT NOSE PADS AND CONTROLLED FUZING TO IMPROVE HEP SHELL PERFORMANCE (C)

by

Bernard A. Rausch

October 1956

Picatinny Arsenal

Dover, N. J.

Technical Report 2372

Ordnance Project TA1-5002H

Dept of the Army Project 5A04-01-001

Approved:
HH Eriksen
for,
D. R. BEEMAN
Acting Director,
Samuel Feltman
Ammunition Laboratories

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OBJECT

To determine the effect of using inert nose pads and selectively assembled modified M91A1 BD fuzes on the ability of T170E3 76 mm HEP-T shell to defeat armor plate.

SUMMARY

It is well known that Composition A-3 loaded HEP shell are not effective at striking velocities above about 1500 fps and at low armor plate obliquities (approximating 0°). Under such conditions the shell filler deflagrates before it can be detonated by the fuze. The use of inert nose pads to reduce the energy imparted to the explosive upon impact and of fuze modifications to bring about quicker and less variable fuze functioning time were considered as promising solutions to this problem. Inert nose pads had been previously tested and been found to successfully prevent deflagration at striking velocities as high as 2600 fps. As a result of this work, a more extensive series of tests using inert nose pads and fuzes with more consistent and rapid initiation times was indicated.

In the limited number of tests conducted, 76 mm T170E3 HEP shell with inert nose pads and either standard or modified M91A1 BD fuzes produced spalls at a striking velocity of approximately 2800 fps and 0° obliquity from 3-inch armor plate in all cases. Against 3-inch plate at 60° obliquity, only shell with the inert nose pad and modified fuze produced spalls in all cases at a striking velocity of approximately 2800 fps. Against 4-inch armor plate at a striking velocity of approximately 2800 fps and 0° obliquity, only those shell with inert nose pads and modified fuzes produced spalls in all cases. At a striking velocity of approximately 1100 fps and 0° obliquity, shell with standard fuzes and shell with inert nose pads and modified fuzes both produced spalls in all cases from 3-inch armor plate and occasionally from 4-inch armor plate; at this velocity and 60° obliquity none of the shell produced spalls.

CONCLUSIONS

T170E3 76 mm HEP shell with inert nose pads and modified M91A1 BD fuzes will consistently defeat 3-inch armor at 0° and 60° obliquity when fired at approximately 2800 fps. These shell and fuzes will also defeat 4-inch armor at a striking velocity of approximately 2800 fps and 0° obliquity.

RECOMMENDATIONS

Various configurations and heights of inert nose pads should be investigated with the purpose of obtaining optimum HEP shell performance, particularly at higher striking velocities.

Standard M91A1 BD fuzes should not be used for tests of HEP shell at striking velocities of over 2000 fps.

INTRODUCTION

1. Poor and inconsistent results are usually obtained when test shell containing HEP fillers are fired at high striking velocities (greater than about 1500 fps) and at low armor plate obliquities (approximately 0°). To prevent deflagration (functioning of the shell filler upon impact with the target plate before the fuze has had time to act), which was believed to be responsible for these failures, nose pads made of an inert material were consolidated in the nose of the shell. The effect of this technique was to cushion and delay impact between the explosive filler and the target, thus allowing more time for the fuze to initiate shell functioning.

2. Results of tests previously conducted (Ref 1) indicated that 76 mm T170E3 HEP-T shell containing nose pads of 90/10 potassium sulfate/ barium stearate or 82/9/9 potassium sulfate/barium stearate/desensitizing wax and a main charge of Composition A-3 would not deflagrate and would produce spalling at striking velocities as high as 2600 fps. It was evident that a more extensive series of tests should be conducted to determine, for various striking velocities, both the low and high velocity functioning characteristics of HEP shell containing nose pads. At the same time, it was felt that experimentation should also cover the use of a redesigned M91A1 BD fuze with a more consistent and rapid initiation time. Picatinny Arsenal has been instrumental in the development of such a fuze (Refs 2 and 3). It was assumed that the combination of an inert nose pad, delaying deflagration at the plate, and faster fuze reaction, making the shell function in a shorter average time, would reduce the incidence of deflagration and increase HEP shell effectiveness.

3. This report contains the results of an investigation of the performance of 76 mm T170E3 HEP-T shell containing inert nose pads and Composition A-3 when assembled with standard M91A1 BD fuzes and with modified M91A1 BD fuzes, and gives the results of test firings at both low and high striking velocities, and at both low and high angles of obliquity against 3-inch and 4-inch armor plate.

RESULTS

4. Four experimental lots of HEP-T shell were loaded, two (Lots PA-E-18579 and PA-E-18580) with Composition A-3 only and two (Lots PA-E-18581 and PA-E-18582) with inert nose pads and Composition A-3. Lots PA-E-18579 and PA-E-18581 were assembled with standard M91A1 BD fuzes and the remaining 2 lots with modified M91A1 BD fuzes. These projectiles were conditioned for a period of at least 16 hours at a temperature of 70°F, were assembled into complete rounds with the propelling

charges required to produce the desired striking velocities, and were fired at 0° and 60° obliquity against 3-inch plate. The armor plate used had Charpy values ranging from 48 to 51 ft-lb at -40°F. The results of these firing tests are reported in Ref 4 and are summarized in Table 1, p 4, and given in detail in Tables 6, 7, 8, and 9 at the end of this report.

5. A number of shell from each group were fired at 0° obliquity and at striking velocities of about 2800 fps and about 1100 fps against 4-inch armor plate. The results of these firing tests are given in detail in Table 10. A summary of these results is shown in Table 2, p 5.

6. Functioning times, from the moment of impact of the shell with the target plate till appearance of the flash caused by shell detonation, were measured for a number of shell in each of the four groups. These times are given in Table 3, p 6.

7. The spall velocities and spall weights were recorded for a number of shell in each of the four groups. These values are given in Table 4, p 7.

DISCUSSION OF RESULTS

8. The results summarized in Table 1 indicate that, regardless of the type of fuze used, 76 mm HEP shell containing inert nose pads will defeat 3-inch armor plate consistently at a plate obliquity of 0° and striking velocities of over 2800 fps. Shell without inert nose pads will not produce spalls regularly under these conditions. It is also to be noted that, when shell containing inert nose pads are fired against 3-inch/0° obliquity armor plate at striking velocities averaging 2800 fps, the spalls produced are larger in diameter and comparable in depth to any which have been recorded, regardless of the striking velocity used. This is an indication that a greater amount of the energy of the detonation had been effectively used to cause plate defeat in shell of this group than in the other shell tested. In addition, only shell of Lot PA-E-18582 (which contained nose pads and modified fuzes) succeeded in consistently spalling 3-inch armor plate placed at 60° obliquity at striking velocities of the order of 2800 fps. It appears that, under conditions of high striking velocity and high or low obliquity, a marked improvement in HEP shell effectiveness can be obtained by using an inert nose pad. A further increase in the functioning efficiency of this type of shell can be realized by using a modified fuze.

TABLE 1

Results of All Firings Against 3-Inch Armor Plate

Lot PA-E-	Filler and Fuze	Obliquity, degrees	Average Striking Velocity, fps	Spalls/Rounds Fired	Average Spall Size Diameter x Thickness, in.
18579	Comp. A-3 and M91A1	0	1240	4/4	6¼ x 3/4
"	" "	0	2800	1/3	8-7/8 x 7/8
"	" "	0	3025	0/1	--
"	" "	60	1070	0/3	--
"	" "	60	2820	2/3	6-3/4 x 7/8
18580	Comp. A-3 and Mod M91A1	0	1130	3/3	5-3/8 x 3/8
"	" "	0	2815	0/3	--
"	" "	0	3030	0/1	--
"	" "	60	1130	0/4	--
"	" "	60	2770	2/3	6¼ x 7/8
18581	Inert nose pad, Comp. A-3 and Mod M91A1	0	1115	5/5	6-3/8 x 3/4
"	" "	0	2810	3/3	7-3/4 x 5/8
"	" "	0	3020	1/1	5-3/4 x ½
"	" "	60	1120	0/5	--
"	" "	60	2810	3/5	6-3/4 x 7/8
"	" "	0	1120	5/5	5 x 5/8
18582	Inert nose pad, Comp. A-3 and Mod M91A1	0	2860	10/10	8-3/4 x 7/8
"	" "	0	3015	1/1	7½ x 3/4
"	" "	60	1120	0/5	--
"	" "	60	2765	10/10	6¼ x 1

TABLE 2

Firings Against 4-Inch Armor Plate

Lot PA-E-	Filler and Fuze	Average Striking Velocity, fps	Spalls/Rounds Fired	Average Spall Size Diameter x Thickness, in.
18579	Comp. A-3 and M91A1	2800	0/2	--
	" "	1100	1/2	5 x 3/4
18580	Comp. A-3 and Mod M91A1	2800	0/3	--
	" "	1225	1/2	5 x 7/8
18581	Inert nose pad, Comp. A-3, and M91A1	2795	1/4	7 x 1-1/8
	" "	1100	1/3	5¼ x 3/8
18582	Inert nose pad, Comp. A-3, and Mod M91A1	2790	5/5	6-7/8 x 3/4
	" "	1130	0/2	--

TABLE 3

Average Functioning Times

Lot PA-E-	Filler and Fuze	Average Functioning Time, microseconds 1200 fps 3 in/0° plate	1200 fps 3 in/60° plate	2800 fps 3 in/0° plate	2800 fps 3 in/60° plate	2800 fps 4 in/0° plate
18579	Comp. A-3, and M91A1	239	289	--	177*	34
18580	Comp. A-3, and Mod M91A1	244*	234	--	164*	29
18581	Inert Nose Pad, Comp. A-3, and M91A1	374*	312	--	156**	195
18582	Inert Nose Pad, Comp. A-3, and Mod M91A1	197*	248	174	184	167

---

*Only one value was recorded under these conditions

**One low value of 46 microseconds was obtained

TABLE 4

Weights and Velocities of Spalls

Lot PA-E-	Filler and Fuze	Striking Velocity, fps	Obliquity, degrees	No. of Spalls Considered	Average Spall Velocity, fps	Average Spall Weight, lb.
18579	Comp. A-3 and M91A1	1200	0	3	720	3.0
		2800	0	1	lost	4.6
18580	Comp. A-3 and M91A1	1200	0	2	820	2.2
18581	Inert Nose Pad, Comp. A-3, and M91A1	1100	0	2	690	4.5
		2800	0*	1	290	5.6
		2860	0	2	650	6.7
18582	Inert Nose Pad, Comp. A-3, and Mod M91A1	1200	0	3	490	2.6
		2800	0	6	715	6.5
		2800	0*	3	340	5.6
		2800	60	9	840	4.3**

---

*Fired against 4-inch armor plate

**Average of 4 spalls; others not recovered

9. Results of firing tests against 4-inch plate (summarized in paragraph 5) show a definite superiority in the performance of shell of Lot PA-E-18582. These shell with inert nose pads and modified fuzes defeated 4-inch armor plate having a Charpy value of 51 ft-lb at -40°F. It appears possible on the basis of these limited tests that 76 mm shell, when redesigned to include inert pads and modified M91A1 BD fuzes, can consistently defeat 4-inch armor plate at high velocities and high and low obliquities. It is probable that the use of inert nose pads and modified fuzes in shell of higher caliber would increase the armor-defeating capabilities of such shell.

10. It is significant that, at striking velocities of about 1100 fps and obliquities of 60°, failure to spall was observed in every group tested. However, a more careful analysis of the firing data (see Table 5, p 9) indicates that shell containing inert nose pads did not damage the armor plate to as great a degree as shell without inert nose pads. Work has been reported (Refs 2 and 3) in which Composition A-3 loaded HEP shell with modified fuzes were fired at striking velocities of about 1000 fps and 60° obliquity. In these firings 16 out of 17 shell succeeded in spalling armor plate. The seventeenth shell caused a hinged spall on the armor. By comparison, very poor results were obtained with shell of Lots PA-E-18581 and -18582. This can probably be attributed to the presence of inert nose pads in these shell which, at these low velocities, prevent adequate quantities of explosive from contacting the plate before fuze initiation occurs. This decreases the amount of energy transferred to the plate. At low velocities, shell containing inert nose pads also have a tendency to skid along the plate making it even more difficult for adequate contact to be established between the shell filler and the plate.

11. Table 1 shows that none of the groups tested at striking velocities of approximately 1100 fps and 60° obliquity produced spalls. Since this ineffectiveness of 76 mm HEP shell at high angles of obliquity when striking at low velocities may be encountered in other calibers, all future programs for the development of HEP shell should include tests at high angles of obliquity over the entire range of striking velocities likely to be required by the using services.

12. An analysis was made of the fuze functioning time data recorded in Tables 6 through 10 and summarized in Table 3. It was noted that:

a. Fuze functioning times were longest at the lower striking velocities but, because recorded data were limited, no definite conclusion could be drawn as to the effect of plate obliquity on fuze functioning time.

TABLE 5

Damage Inflicted by Shell Containing Inert Nose Pads

Lot PA-E-	Filler and Fuze	Hinged Spalls	Angle of Hinge, degrees	Bulges	Extent of Crack in Bulge, degrees
18579	Comp. A-3 and M91A1	1	320	1	70
18580	Comp. A-3 and Mod M91A1	2	290 270	2	200 250
18581	Inert Nose Pad, Comp. A-3, and M91A1	0	--	5*	70 70 45
18582	Inert Nose Pad, Comp. A-3, and Mod M91A1	0	--	5	None**

---

*Two bulges were not cracked

**These bulges were slight

b. At a striking velocity of approximately 1200 fps, inert nose pad-loaded shell assembled with modified M91A1 BD fuzes and fired against armor plate at 60° obliquity had faster functioning times than the same shell fuzed with standard M91A1 BD fuzes:

	Standard Fuze	Modified Fuze
Shell Tested	5	4
Average Functioning Time, microsec	312	248
Standard Deviation, microsec	12	24

Against 60° oblique armor plate at a striking velocity of approximately 2800 fps, inert nose pad-loaded shell had approximately the same functioning times whether they were assembled with standard or with modified M91A1 BD fuzes:

	Standard Fuze	Modified Fuze
Shell Tested	3*	9
Average Functioning Time, microsec	193	184
Standard Deviation, microsec	8	12

---

*A fourth shell, which had an abnormally low functioning time of 46 microseconds, was not considered

As the striking velocity increased from about 1200 fps to about 2800 fps the disparity in functioning times between shell assembled with standard fuzes and shell assembled with modified fuzes decreased. At 2800 fps the shell loaded with modified fuzes functioned about 5% faster than standard-fuzed shell while at 1200 fps the former functioned about 25% faster than the latter.

13. Two shell containing Composition A-3 and assembled with standard fuzes and 3 shell containing Composition A-3 and assembled with modified fuzes failed to cause spalling when fired against 4-inch armor plate at 2800 feet per second striking velocity. The functioning times recorded for these 5 shell averaged only 31 microseconds which is a definite indication that shell functioning began as a result of impact before the fuze could cause initiation (Ref 5). In direct contrast is the behavior of a group of 5 shell containing inert nose pads and modified fuzes. These shell spalled 4-inch armor plate in every case and had functioning times averaging 167 microseconds. This indicates that the effectiveness of HEP shell can be increased by using inert nose pads. Results of firing inert nose pad-loaded shell with standard fuzes were poor; only 1 of 4 rounds spalled 4-inch armor. It appears that because of the inferior results experienced at high striking velocities and high obliquities against 4-inch armor, the use of standard M91A1 BD fuzes should be discontinued in all further tests under these firing conditions.

14. Because of the high cost of press-loading, efforts have been made to develop a castable explosive charge for HEP shell. In recent tests (Ref 6), 76 mm T170E5 shell were cast-loaded with 75/25 octol (HMX/TNT) and fired so as to strike normal to 3-inch armor plate. At velocities of 2000 fps to 2400 fps, 8 out of 12 of these shell (which did not have inert nose pads) produced spalls. In view of these test results, further work on HEP shell containing inert nose pads should include castable fillers. Various configurations and heights of pressed and cast inert nose pads should also be investigated.

EXPERIMENTAL PROCEDURE

15. The following materials were used:

a. Composition A-3, conforming to Specification JAN-C-440, 31 January 1947.

b. Potassium sulfate, conforming to Specification JAN-P-193, 20 July 1953, except for the granulation which was as follows:

0% retained on U.S. Standard Sieve No. 12
50% " " " " " " 25
16% " " " " " " 50
7% " " " " " " 70
9% " " " " " " 100
11% " " " " " " 200
7% through U.S. Standard Sieve No. 200

c. Barium stearate, conforming to Specification JAN-B-366, 15 July 1946.

d. Desensitizing wax, conforming to Specification PA-PD-535, 15 September 1954.

16. Shell of Lots PA-E-18579 and -18580 were loaded with Composition A-3, in accordance with Figure 1, in 5 increments of 12, 12, 10, 6, and 4 ounces. Each increment was consolidated with a punch 2.04 inches in diameter at a pressure of 8000 psi (13.0 tons dead load). Shell of Lots PA-E-18581 and -18582 were loaded in accordance with Figure 2. One 10-oz increment of 82/9/9 potassium sulfate/barium stearate/desensitizing wax was placed in the nose of the shell, followed by 4 increments (12, 11, 7, and 6 ounces) of Composition A-3. Each increment was consolidated with a punch 2.04 inches in diameter at a pressure of 8000 psi (13.0 tons dead load).

17. The desensitizing wax used in the inert mixture was chilled with dry ice and shredded in a Stokes oscillating granulator to obtain 20-mesh wax. The potassium sulfate and barium stearate were blended with the wax by mixing in a rotating drum.

18. The fuzes used in Lots PA-E-18581 and -18582 were modified, in accordance with Figure 3, to have an average percussion plunger travel of .030 inch ("A" dimension .480 inch). This is .060 inch shorter than the average plunger travel of the standard M91A1 fuze. Plunger travel is the distance of travel of the firing pin point from the armed position to the sensitive surface of the detonator.

19. The fuze functioning times were obtained by means of a streak camera. An insulated copper screen was placed against the plate at the point of impact. From this copper screen a lead was run to a Microflash unit connected in series with a high voltage source grounded to the armor plate. When the round was fired, the projectile shorted the copper screen with the plate thus setting off the Microflash unit whose flash was recorded on the streak film as zero time. Timing lines of 10-kilocycle frequency were placed on the film by an oscillator. The flash caused by shell detonation was also recorded and the time interval between the 2 flashes measured. An intermediate streak caused by plate flash was disregarded when measuring the fuze functioning time.

20. All shell were fired from a 76 mm T124E2 gun (using M6 propellant of Lot RAD-38038 with a web of .0300 inch) at a range of 300 feet.

REFERENCES

1. D. E. Seeger, B. A. Rausch, K. G. Sheffield, Effect of Inert Nose Pads on Functioning of T170E3 76 mm HEP-T Shell, Picatinny Arsenal Technical Report 2207, October 1955

2. Jefferson Proving Ground Firing Record No. A-10009

3. Jefferson Proving Ground Firing Record No. A-13698

4. Jefferson Proving Ground Firing Record No. A-20790

5. M. J. Margolin, E. A. Skettini, Determination of the Time Interval Between Impact and Deflagration of 75 mm T165E11 Composition A-3 HEP-T Shell, Picatinny Arsenal Technical Report 2281, March 1956

6. Jefferson Proving Ground Firing Record No. A-19749

7. Picatinny Arsenal General Laboratory Report 52-H1-1020, 9 April 1952

TABLE 6

Results of Functioning Test, Lot PA-E-18579[a]

PA Shell Number	Propellant Charge, oz[b]	Plate Obliquity, degrees	Striking Velocity, fps	Facial Impression,[d] Diameter x Depth, in.	Spall Cavity, Diameter x Depth, in.	Spall Velocity, fps	Spall Weight, lb	Functioning Time, microsec
7	14	0	1187	$6\frac{1}{4}$ x $\frac{1}{4}$	6-3/4 x 3/4	801	3.60	226
8	12	0	1226	$5\frac{1}{2}$ x 3/8	5-3/4 x 3/4	696		251
9	12	0	1241	6-1/8 x $\frac{1}{2}$	$6\frac{1}{2}$ x 7/8	670	2.45	Lost
117	17	0	1318	$6\frac{1}{4}$ x 3/8	$6\frac{1}{2}$ x 3/4	Lost		Lost
124	57	0	2777	$8\frac{1}{2}$ x 3/8	9 x 7/8	Lost	4.65	Lost
123	57	0	2804	c	SB	--		Lost
125	57	0	2816	c	VSB	--		Lost
129	62.5	0	3024	c	VVSB	--		Lost
120	9	60	936	$6\frac{1}{4}$ x 3/8	SB	--		424
116	12	60	1025	$6\frac{1}{4}$ x 3/8	BWC	--		Lost
115	12	60	1110	$6\frac{1}{4}$ x 3/8	HS	--		283
128	57	60	2788	$8\frac{1}{4}$ x $\frac{1}{4}$	BWC	—		177
126	57	60	2820	9 x 3/8	6-3/4 x 7/8	Lost		Lost
127	57	60	2857	$9\frac{1}{4}$ x $\frac{1}{4}$	$7\frac{1}{4}$ x 3/4	--		Lost

---

[a] 76 mm T170E3 HEP-T shell completely loaded with Composition A-3 and assembled with M91A1 BD fuzes were fired against 3-inch homogeneous armor plate having an average Charpy value of 49 ft-lbs at -40°F.

[b] Propellant used was Lot RAD-38038, web .0300 inch

[c] 2 inch brass disc in center of target area

[d] Facial impressions obtained at 60° plate obliquity were elliptical. Diameter measurement shown is the average of major and minor diameters

HS - Hinged spall
BWC - Bulge with crack
SB - Small bulge
VSB - Very small bulge
VVSB - Very very small bulge

TABLE 7

Results of Functioning Test, Lot PA-E-18580[a]

PA Shell Number	Propellant Charge, oz[b]	Plate Obliquity, degrees	Striking Velocity, fps	Facial Impression,[d] Diameter x Depth, in.	Spall Cavity, Diameter x Depth, in.	Spall Velocity, fps	Spall Weight, lb	Functioning Time, microsec
143	12	0	1098	5-1/8 x $\frac{1}{2}$	$10\frac{1}{4}$ x 1-1/8	Lost	3.16	Lost
142	12	0	1110	$5\frac{1}{2}$ x 3/8	5-3/4 x 5/8	912		Lost
141	14	0	1178	$5\frac{1}{2}$ x 3/8	$5\frac{1}{4}$ x 3/4	732	1.14	244
155	57	0	2789	c	VSB	--		Lost
154	57	0	2810	c	VSB	--		Lost
153	57	0	2839	c	VSB	--		Lost
159	62.5	0	3032	$7\frac{1}{2}$ x 3/8	None	--		Lost
144	12	60	1084	$5\frac{1}{2}$ x 3/8	BWC	--		Lost
146	12	60	1084	5-3/4 x 3/8	HS	--		255
138	11	60	1111	5-3/4 x $\frac{1}{4}$	HS	--		223
145	57	60	1148	6 x $\frac{1}{4}$	BWC	--		224
158	57	60	2708	$8\frac{1}{2}$ x $\frac{1}{4}$	$6\frac{1}{2}$ x 7/8	Lost		164
157	57	60	2789	8-3/4 x 3/8	5-3/4 x 1	Lost		Lost
156	57	60	2818	9 x 3/8	B	--		Lost

---

[a] 76 mm T170E3 HEP-T shell completely loaded with Composition A-3 and assembled with M91A1 BD Mod Type I fuzes were fired against 3-inch homogeneous armor plate having an average Charpy value of 49 ft-lbs at -40°F

[b] Propellant used was Lot RAD-38038, web .0300 inch

[c] Brass disc in center of target area

[d] Facial impressions obtained at 60° plate obliquity were elliptical. Diameter measurement shown is the average of major and minor diameter

HS - Hinged spall
BWC - Bulge with crack
B - Bulge
VSB - Very small bulge

TABLE 8

Results of Functioning Test, Lot PA-E-18581[a]

PA Shell Number	Propellant Charge, oz[b]	Plate Obliquity, degrees	Striking Velocity, fps	Facial Impression,[c] Diameter x Depth, in.	Spall Cavity, Diameter x Depth, in.	Spall Velocity, fps	Spall Weight, lb	Functioning Time, microsec
24	12	0	1079	5½ x 3/8	6½ x 5/8	465	4.56	Lost
23	12	0	1097	5¼ x 3/8	6 x 7/8	Lost		Lost
25	12	0	1129	5-3/4 x 3/8	6½ x 3/4	615	4.36	Lost
22	12	0	1131	5½ x 3/8	6¼ x 3/4	900		374
21	12	0	1148	5-3/4 x 3/8	6¼ x 1	Lost		Lost
42	57	0	2780	8¼ x ½	6-3/8 x ½	429		Lost
43	57	0	2817	8¼ x 3/8	8-3/4 x 5/8	Lost	6.60	Lost
41	57	0	2830	8-3/4 x 3/8	8½ x 3/4	738	6.73	Lost
49	62.5	0	3017	8¼ x ½	5-3/4 x ½	783		Lost
26	12	60	1092	6¼ x 1	B	--		328
27	12	60	1104	6 x ¼	B	--		314
28	12	60	1116	6 x 3/8	BWC	--		317
29	12	60	1136	6¼ x 3/8	BWC	--		294
30	12	60	1154	6 x ¼	BWC	--		307
47	57	60	2780	7-3/4 x 3/8	HS	--		202
46	57	60	2798	8 x 3/8	BWC	--		189
44	57	60	2847	8¼ x 3/8	6-3/4 x 1	Lost		Lost
45	57	60	Lost	8½ x 3/8	6¼ x 3/4	Lost		187
48	57	60	Lost	8 x 3/8	7 x 7/8	Lost		46

---

[a] 76 mm T170E3 HEP-T shell loaded with a nose pad of 82/9/9 potassium sulfate/barium stearate/desensitizing wax and an upper charge of Composition A-3 and assembled with M91A1 BD fuzes were fired against 3-inch homogeneous plate having an average Charpy value of 49 ft-lbs at -40°F.

[b] Propellant used was Lot RAD-38038, web .0300 inch

[c] Facial impressions obtained at 60° plate obliquity were elliptical. Diameter measurement shown is the average of major and minor diameters

HS - Hinged spall
BWC - Bulge with crack
B - Bulge

TABLE 9

Results of Functioning Test, Lot PA-E-18582[a]

PA Shell Number	Propellant Charge, oz[b]	Plate Obliquity, degree	Striking Velocity, fps	Facial Impression,[c] Diameter x Depth, in.	Spall Cavity, Diameter x Depth, in.	Spall Velocity, fps	Spall Weight, lb	Functioning Time, microsec
68	12	0	1082	5-1/8 x ¼	5¼ x 5/8	416	2.58	Lost
69	12	0	1082	5¼ x ¼	5¼ x 5/8	321		Lost
67	12	0	1105	5¼ x 3/8	5½ x 5/8	Lost		Lost
66	12	0	1111	5 x 3/8	4½ x 3/4	Lost		Lost
65	12	0	1227	5¼ x 5/16	5-3/8 x 5/8	743	0.41[d]	197
86	57	0	2704	8¼ x 3/8	9 x 3/4	896	6.77	Lost
88	57	0	2737	8½ x 3/8	8¼ x 7/8	Lost		Lost
94	57	0	2768	8-3/8 x 3/8	8-3/4 x 7/8	725	7.06	191
93	57	0	2771	8½ x 3/8	8½ x 5/8	754	6.19	164
92	57	0	2773	8¼ x 3/8	8-3/4 x 1	704	6.90	175
85	57	0	2777	8½ x 3/8	9 x 7/8	Lost		Lost
91	57	0	2786	8½ x 3/8	9¼ x 7/8	709		166
89	57	0	2795	8½ x 3/8	8-3/4 x 3/4	Lost	5.69	Lost
87	57	0	2802	8¼ x 3/8	8-3/4 x 7/8	Lost		Lost
90	57	0	2821	7½ x ¼	8¼ x 7/8	529	6.44	Lost
105	62.5	0	3013	7½ x 3/8	7½ x 3/4	895		Lost

---

[a] 76 mm T170E3 HEP-T shell loaded with a nose pad of 82/9/9 potassium sulfate/barium stearate/desensitizing wax and an upper charge of Composition A-3 and assembled with M91A1 BD Mod Type I fuzes were fired against 3-inch homogeneous plate having an average Charpy value of 49 ft-lbs at -40°F

[b] Propellant used was Lot RAD-38038, web .0300 inch

[c] Facial impressions obtained at 60° plate obliquity were elliptical. Diameter measurement shown is the average of major and minor diameters

[d] Only one part of spall recovered

TABLE 9 (CONT)

PA Shell Number	Propellant Charge, oz[b]	Plate Obliquity, degrees	Striking Velocity, fps	Facial Impression,[c] Diameter x Depth, in.	Spall Cavity, Diameter x Depth, in.	Spall Velocity, fps	Spall Weight, lb	Functioning Time, microsec
71	12	60	1078	5-3/4 x ¼	SB	--		223
70	12	60	1095	5-3/4 x ¼	SB	--		Lost
73	12	60	1098	6 x 3/8	SB	--		265
72	12	60	1219	6 x ¼	SB	--		231
74	12	60	Lost	5-3/4 x ¼	SB	--		273
101	57	60	2745	7-3/8 x ½	6¼ x 1¼	1027	4.27	176
98	57	60	2755	7-3/4 x ½	6½ x 3/4	802		193
103	57	60	2758	7-3/8 x ½	6 x 7/8	857	4.26	192
104	57	60	2763	7½ x ½	6 x 1	863	4.65	185
100	57	60	2765	8¼ x 5/8	6¼ x 1	861		207
102	57	60	2772	7¼ x 5/8	6½ x 1-1/8	796		187
99	57	60	2776	7-3/4 x ½	6½ x 7/8	870	4.14	177
96	57	60	2780	8-3/8 x ¼	6 x 7/8	585		168
95	57	60	2783	8½ x 3/8	6¼ x 5/8	Lost		Lost
97	57	60	Lost	7-3/4 x 7/8	6-3/4 x 3/4	Lost		173

SB - Small bulge

TABLE 10

Functioning Tests Against 4-Inch Armor Plate*

Lot Number	PA Shell Number	Propellant Charge, oz	Striking Velocity, fps	Facial Impression, Diameter x Depth, in.	Spall Cavity, Diameter x Depth, in.	Spall Velocity, fps	Spall Weight, lb	Functioning Time, microsec
PA-E-18579	132	12	1108	6 x ½	5¼ x 3/4	644		252
"	133	12	1121	5 x 3/4	B	--		153
				5¼ x 5/8	BWC	--		194
PA-E-18580	205	12	1222					
"	201	12	1231	5½ x ½	5 x 7/8	Lost		205
PA-E-18581	206	12	1094	5½ x 5/8	B	--		266
"	202	12	1105	5¼ x 5/8	B	--		262
"	37	10	1107	5½ x ¼	5¼ x 3/8	Lost		Lost
PA-E-18582	110	12	1132	5¼ x ½	B	--		266
"	111	12	1145	5¼ x ½	B	--		216
PA-E-18579	119	57	2799	**	None	--		49
"	118	57	2804	**	None	--		19
PA-E-18580	176	57	2301	**	None	--		19
"	183	57	2801	**	None	--		49
"	179	57	2803	**	None	--		19
PA-E-18581	35	57	2788	8½ x 3/8	B	--		190
"	33	57	2796	8½ x ½	7 x 1-1/8	289	5.62	189
"	32	57	2801	7-3/4 x 5/8	SB	--		Lost
"	34	57	2301	8-3/4 x 3/8	B	--		205
PA-E-18582	79	57	2783	8½ x 3/8	7 x 3/4	397		178
"	76	57	2786	8¼ x 5/8	7 x 1	448	5.65	169
"	78	57	2786	8½ x 3/8	7 x 7/8	Lost	5.82	167
"	75	57	2793	8½ x 5/8	7¼ x 3/4	261		157
"	77	57	2794	7-3/4 x ½	6-3/4 x 3/4	259	5.42	166

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*All shell were fired at 0^o obliquity

**2 in. brass disc in center of target area

B - bulge
B.C - bulge with crack
SB - small bulge

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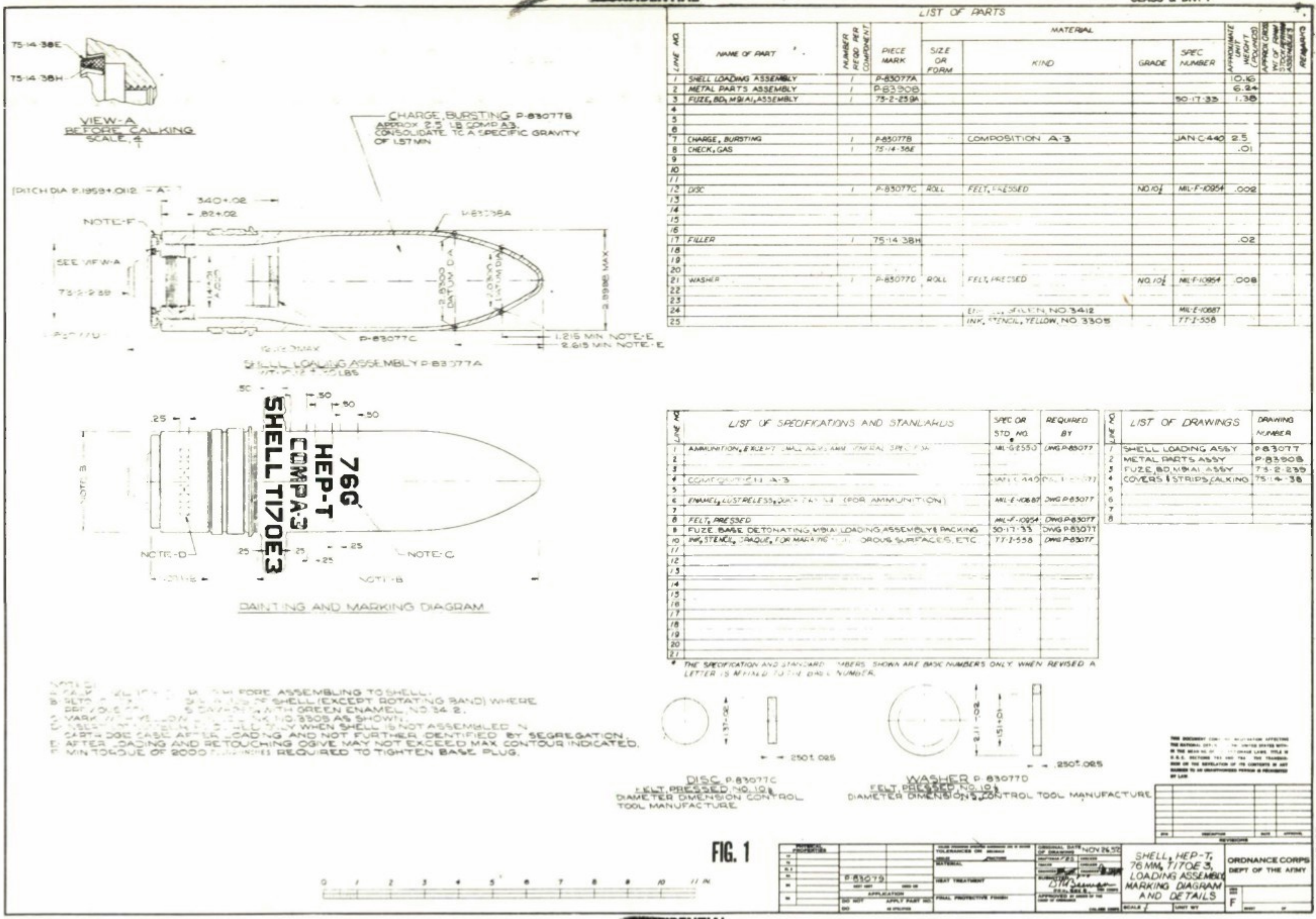

LIST OF PARTS

LINE NO	NAME OF PART	NUMBER REQD PER COMPONENT	PIECE MARK	MATERIAL: SIZE OR FORM	MATERIAL: KIND	MATERIAL: GRADE	MATERIAL: SPEC NUMBER	APPROXIMATE UNIT WEIGHT (POUNDS)	APPROX GROSS WT OF RAW STOCK PER ASSEMBLY	REMARKS
1	SHELL LOADING ASSEMBLY	1	P-83077A					10.16		
2	METAL PARTS ASSEMBLY	1	P-83308					6.24		
3	FUZE, BD, M91A1, ASSEMBLY	1	73-2-239A				50-17-33	1.38		
4										
5										
6										
7	CHARGE, BURSTING	1	P-83077B		COMPOSITION A-3		JAN-C-440	2.5		
8	CHECK, GAS	1	75-14-38E					.01		
9										
10										
11										
12	DISC	1	P-83077C	ROLL	FELT, PRESSED	NO. 10½	MIL-F-10954	.002		
13										
14										
15										
16										
17	FILLER	1	75-14-38H					.02		
18										
19										
20										
21	WASHER	1	P-83077D	ROLL	FELT, PRESSED	NO. 10½	MIL-F-10954	.008		
22										
23										
24					ENAMEL, GREEN, NO. 3412		MIL-E-10687			
25					INK, STENCIL, YELLOW, NO 3305		TT-I-558			

LINE NO	LIST OF SPECIFICATIONS AND STANDARDS	SPEC OR STD NO.*	REQUIRED BY
1	AMMUNITION, EXCEPT SMALL ARMS AMM GENERAL SPEC FOR	MIL-G-2550	DWG P-83077
2			
3			
4	COMPOSITION A-3	JAN-C-440	DWG P-83077
5			
6	ENAMEL, LUSTRELESS, QUICK DRYING (FOR AMMUNITION)	MIL-E-10687	DWG P-83077
7			
8	FELT, PRESSED	MIL-F-10954	DWG P-83077
9	FUZE, BASE DETONATING M91A1 LOADING ASSEMBLY & PACKING	50-17-33	DWG P-83077
10	INK, STENCIL, OPAQUE, FOR MARKING [illegible] POROUS SURFACES, ETC	TT-I-558	DWG P-83077
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			

* THE SPECIFICATION AND STANDARD NUMBERS SHOWN ARE BASIC NUMBERS ONLY. WHEN REVISED A LETTER IS AFFIXED TO THE BASIC NUMBER.

LINE NO	LIST OF DRAWINGS	DRAWING NUMBER
1	SHELL LOADING ASSY	P-83077
2	METAL PARTS ASSY	P-83308
3	FUZE, BD, M91A1 ASSY	73-2-239
4	COVERS & STRIPS, CALKING	75-14-38
5		
6		
7		
8		

NOTES:
A. CALK [illegible] BEFORE ASSEMBLING TO SHELL.
B. RETOUCH [illegible] SURFACES OF SHELL (EXCEPT ROTATING BAND) WHERE PREVIOUS [illegible] IS DAMAGED, WITH GREEN ENAMEL, NO. 34-2.
C. MARK WITH YELLOW [illegible] INK NO. 3305 AS SHOWN.
D. INSERT [illegible] WHEN SHELL IS NOT ASSEMBLED IN CARTRIDGE CASE AFTER LOADING AND NOT FURTHER IDENTIFIED BY SEGREGATION.
E. AFTER LOADING AND RETOUCHING OGIVE MAY NOT EXCEED MAX CONTOUR INDICATED.
F. MIN TORQUE OF 2000 [illegible] REQUIRED TO TIGHTEN BASE PLUG.

FIG. 1

Fig 1 Original Design of T170E3 HEP Shell

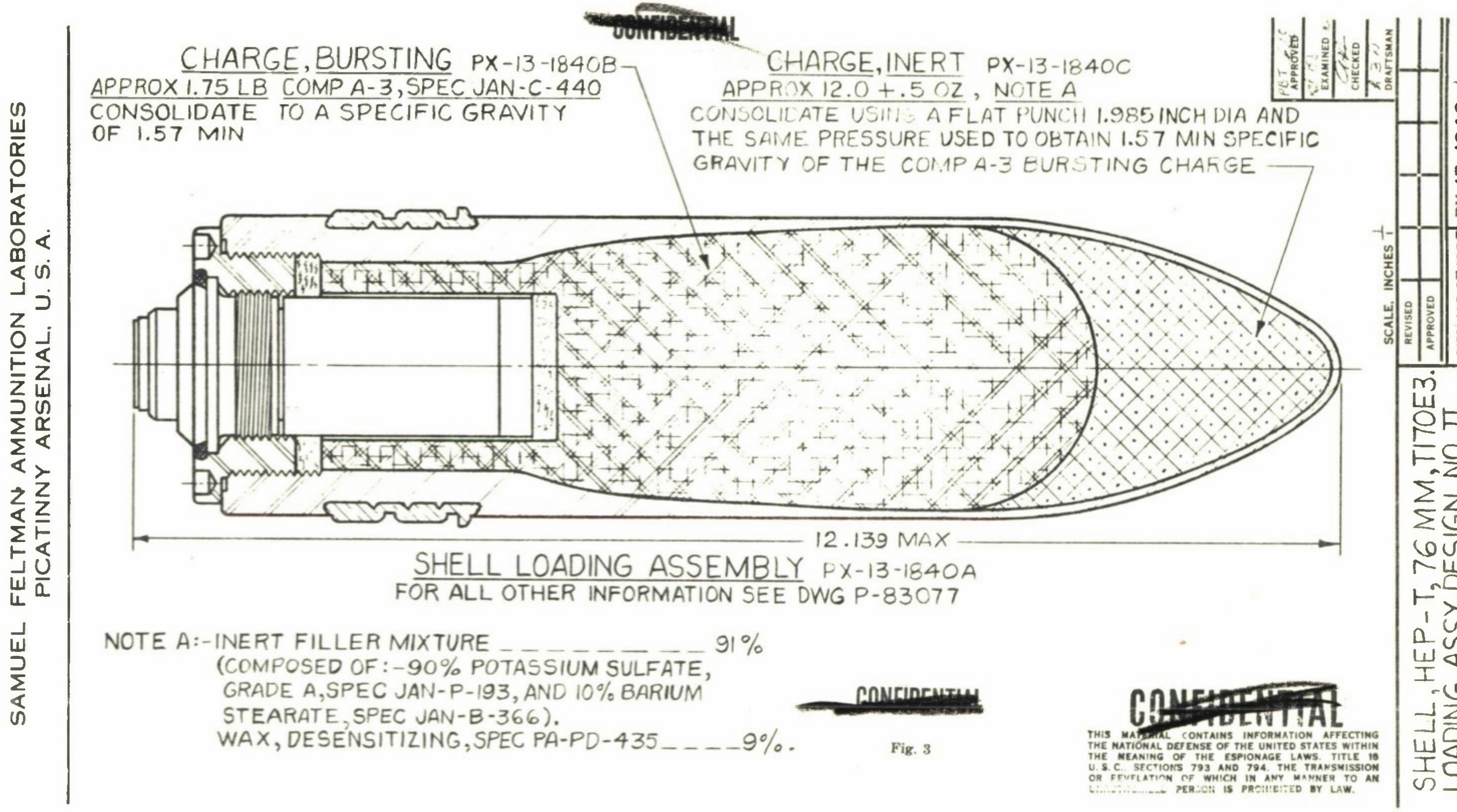

Fig 2 Loading Assembly of T170E3 HEP Shell, Design No. 2

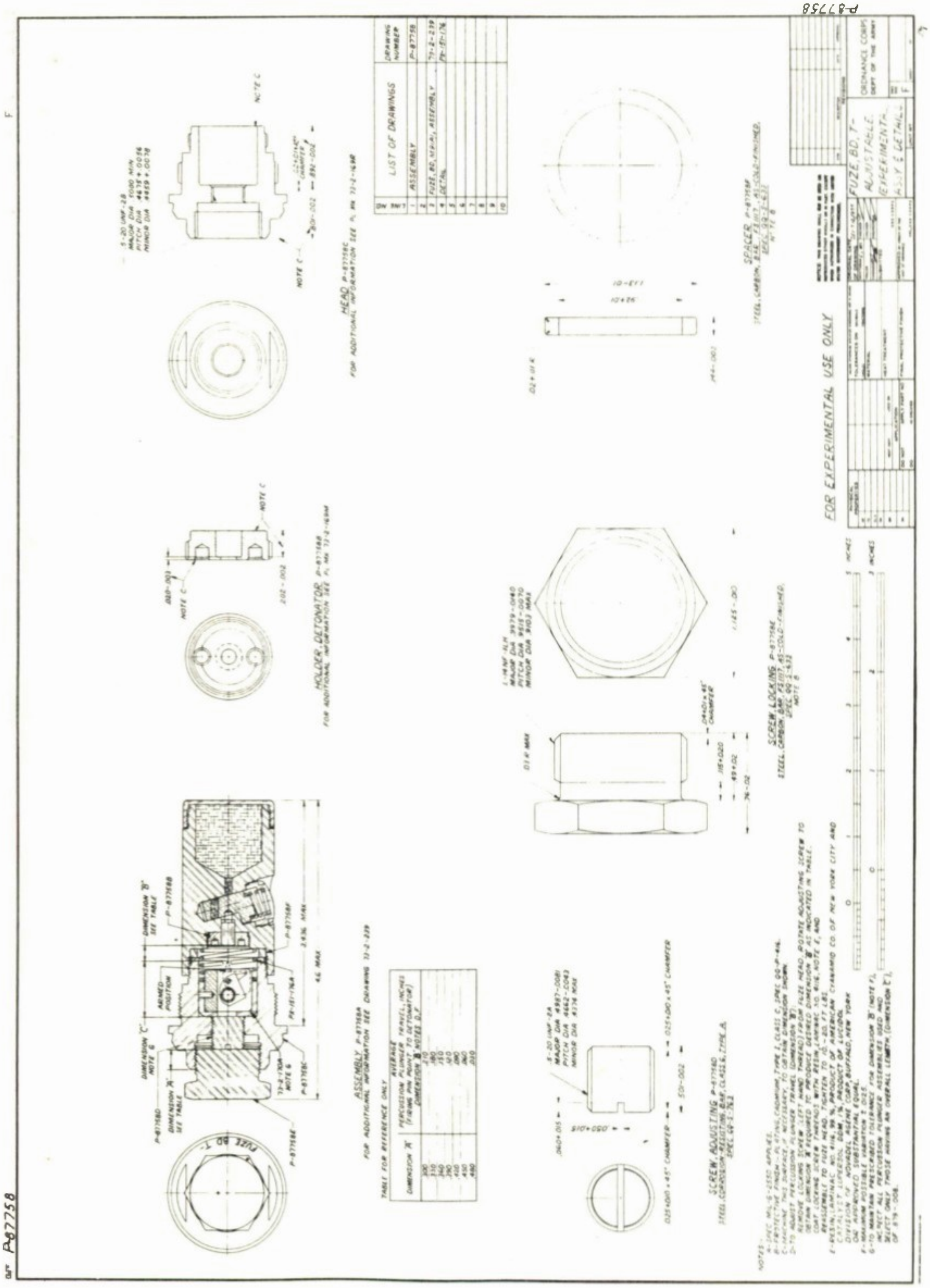

Fig 3 Modified M91A1 Base-Detonating Fuze

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